Section 3
State of the Great Lakes Based on Indicators

The status of the chemical, physical, and biological integrity of the waters of the Great Lakes basin ecosystem has been assessed and is considered mixed because:

- Surface waters are still amongst the best sources of drinking water in the world;
- Progress has been made both in cleaning up contaminants and in rehabilitating some fish and wildlife species;
- Invasive species continue as a significant threat to Great Lakes biological communities;
- Atmospheric deposition of contaminants from distant sources outside the basin confounds efforts to eliminate these substances;
- Urban sprawl threatens high quality natural areas, rare species, farmland and open space; and
- Development, drainage, and pollution are shrinking coastal wetlands.

These conclusions are based on assessments of 33 indicators made by the governments of Canada, United States, Provinces, States, Tribes, and First Nations, including local governments, industry, academia, and non-governmental organizations. The indicators are part of suite of 80 that have been determined to be necessary, sufficient and feasible in order to convey a picture of Great Lakes basin health. Several categories comprise the suite: **open and nearshore waters, coastal wetlands, nearshore terrestrial, land use, human health, societal,** and **unbounded** (those indicators that transcend the other categories - for example, Acid Rain or indicators of climate change).

The assessment is incomplete. Data for several indicators within this report are uneven (or not basin-wide) across jurisdictions. Of a total of 80 Great Lakes ecosystem indicators, 47 have yet to be reported or require further development. In some cases, the required data have not been collected. Changes to existing monitoring programs or the initiation of new monitoring programs are also needed. Several indicators are under development. More research or testing may be needed before these indicators can be assessed.

This section details the purpose, state, and future pressures for each of the 33 indicators that were analyzed. The authors of the indicator reports were asked to assess, in his or her best professional judgment, the overall status of the ecosystem component in relation to established endpoints or ecosystem objectives, when available. Five broad categories were used:

- **Good.** The state of the ecosystem component is presently meeting ecosystem objectives or otherwise is in acceptable condition.
- **Mixed, Improving.** The ecosystem component displays both good and degraded features, but overall, conditions are improving toward an acceptable state.
- **Mixed.** The state of the ecosystem component has some features that are in good condition and some features that are degraded, perhaps differing between lake basins.
- **Mixed, Deteriorating.** The ecosystem component displays both good and degraded features, but overall, conditions are deteriorating from an acceptable state.

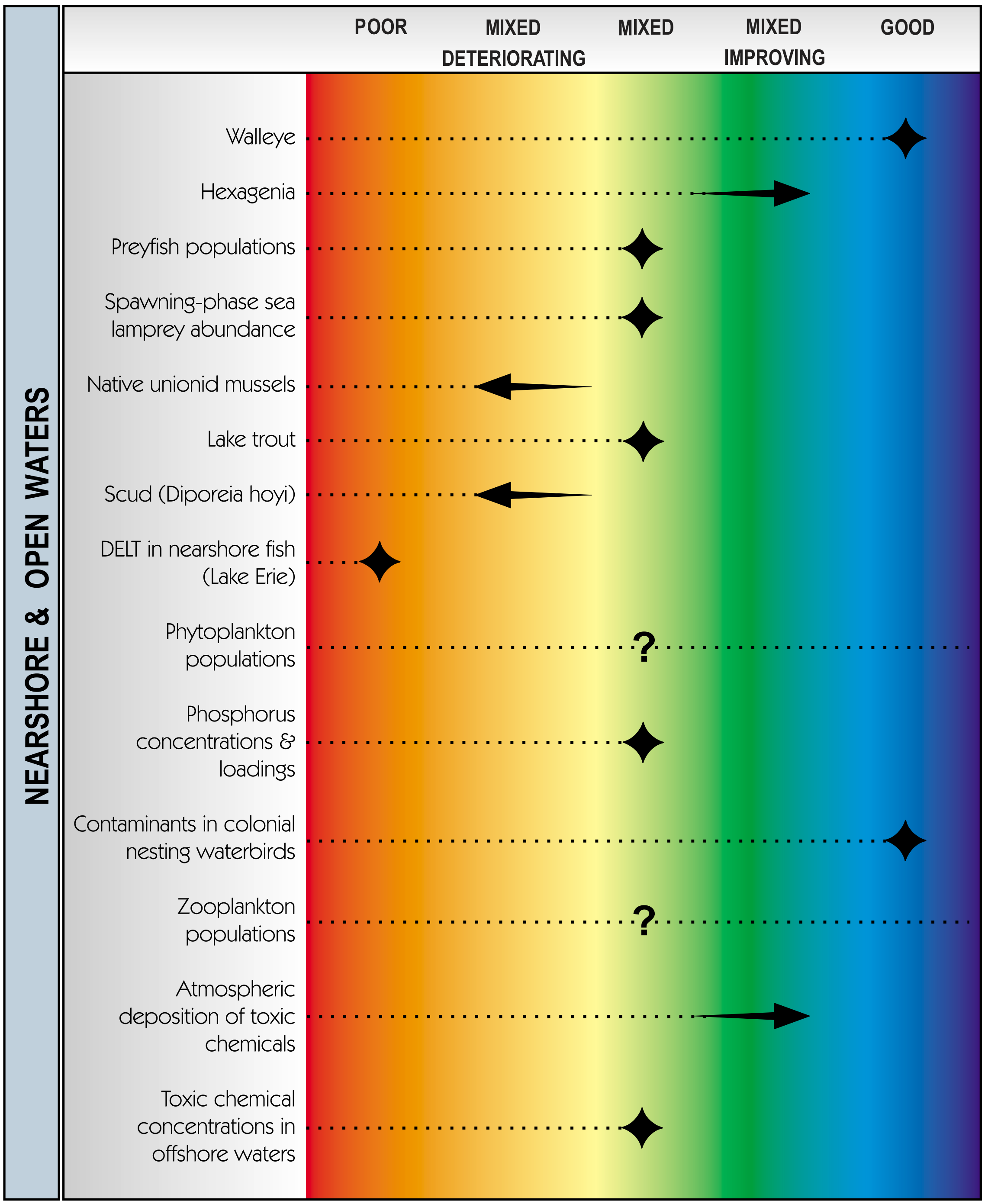
- **Poor.** The ecosystem component is severely negatively impacted and it does not display even minimally acceptable conditions.

Over the next several State of the Lakes Ecosystem Conferences, additional indicators will be developed, monitoring programs will be adjusted, information management systems put into place, and research and testing completed to refine the indicators. A robust suite of indicators will strengthen the biennial assessment of the status of the Great Lakes.

The Great Lakes community is encouraged to assist in this assessment by exploring the detailed indicator summaries and conclusions, and providing feedback on the content, format, conclusions, and implications for management. The complete indicator reports for these 33 indicators can be found in ***Implementing Indicators, November 2000.***

3.1 Nearshore & Open Waters

Nearshore and Open Water Indicators - Assessment at a Glance

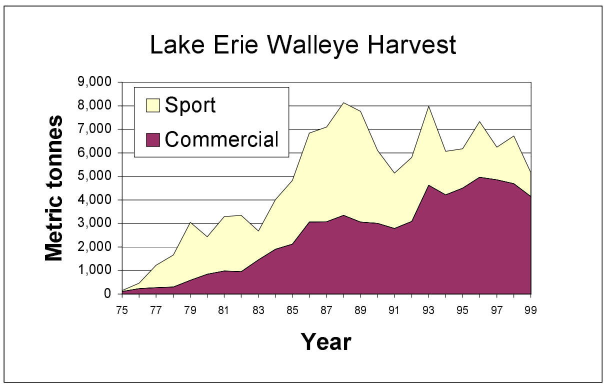


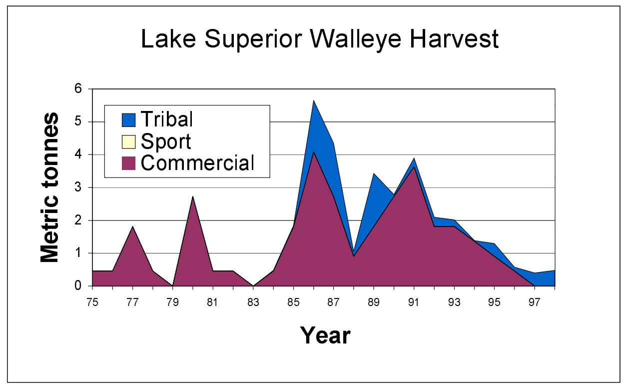
Walleye

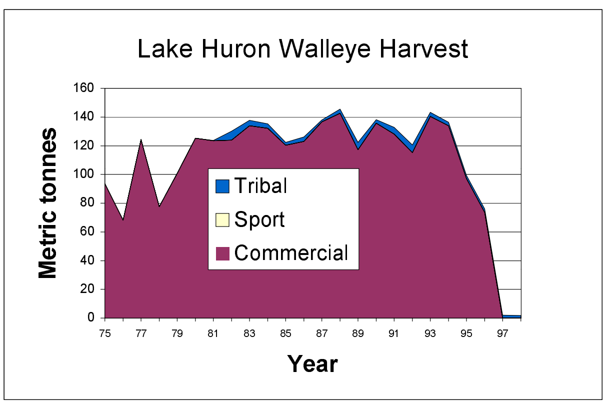
Assessment: Good

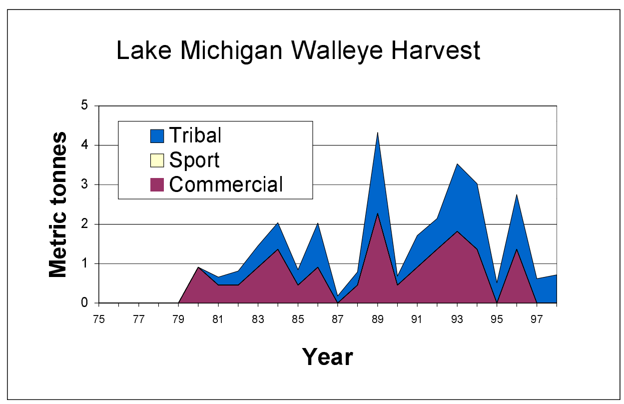
Purpose
Trends in the amount of walleye harvested indicate changes in overall fish community structure, the health of percids (the family of fish to which walleye belong), and the stability and resiliency of the Great Lakes aquatic ecosystem.

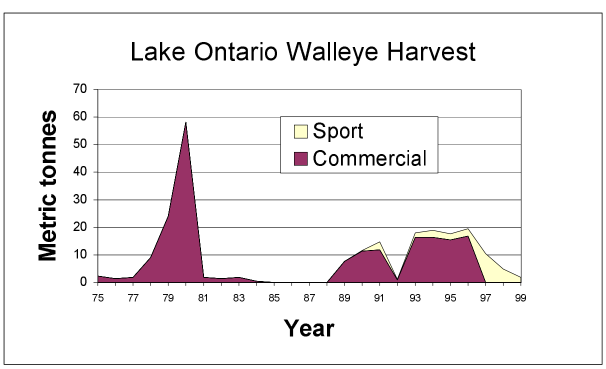
State of the Ecosystem
In general, walleye yields peaked during periods of environmental conditions that favoured walleye (mid-1980s), and they remain substantially improved from levels of the 1970s. Total yields were highest in Lake Erie, intermediate in Lakes Huron and Ontario, and lowest in Lakes Michigan and Superior, as shown by the historical pattern before the 1930s. Declines in the 1990s were likely related to shifts in environmental states, i.e., reduced nutrient levels in the water, changing fisheries, and, perhaps in Lake











Walleye harvests for each of the Great Lakes.
(Note: Established Fish Community Goals and Objectives are: Lake Huron: 700 metric tonnes, Lake Michigan: 100-200 metric tonnes, Lake Erie: sustainable harvests in all basins. Achievement of these targets will require healthy walleye stocks in each lake.)
Source: Tom Stewart (Lake Ontario-OMNR), Tom Eckhart (Lake Ontario-NYDEC), Dave Fielder (Lake Huron-MDNR), various annual OMNR and ODNR Lake Erie fisheries reports, and the GLFC commercial fishery data base

Erie, a population naturally coming into balance with its prey base.

Future Pressures

Walleye populations will be influenced by loss of habitats; environmental factors that alter water levels, water temperature, water clarity, and flow (currents); climate change impacts; non-native species, like zebra mussels, ruffe, and round gobies; and human disturbance of tributary and nearshore habitats through activities like dredging, diking, farming, and filling of wetlands.

Acknowledgments

Author: Roger Knight, Ohio Department of Natural Resources.

Fishery harvest data were obtained from Tom Stewart (Lake Ontario-OMNR), Tom Eckhart (Lake Ontario-NYDEC), Karen Wright (Upper Lakes tribal data-COTFMA), Dave Fielder (Lake Huron-MDNR), Terry Lychwyck (Green Bay-WDNR), various annual OMNR and ODNR Lake Erie fisheries reports, and the GLFC commercial fishery data base. Gene Emond (ODNR) collated data into a standardized form. Fishery data should not be used for purposes outside of this document without first contacting the agencies that collected them.

Hexagenia

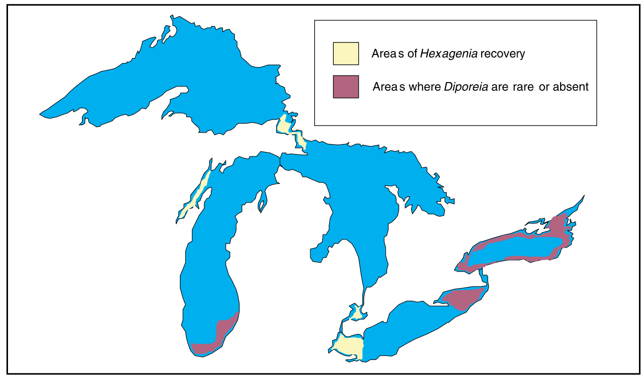
Assessment: Mixed, improving

Purpose

Hexagenia (or burrowing mayfly) is intolerant of pollution and thus reflects the quality of water and lakebed sediments in mesotrophic Great Lakes habitats (moderate nutrient levels). It was historically an important item in the diets of many valuable fishes, and the massive swarms of winged adults that are typical of healthy, productive *Hexagenia* populations are highly visible.

State of the Ecosystem

There is now evidence that *Hexagenia* have begun to recover in Green Bay (Lake Michigan), Saginaw Bay (Lake Huron), and the Western Basin of Lake Erie, and that they have fully recovered in the southwestern part of the Western Basin of Lake Erie. Most of Lake St. Clair and portions of the upper Great Lakes connecting channels support populations of *Hexagenia* with the highest biomass and production measured anywhere in North America. In sharp contrast, *Hexagenia* have been extirpated (eliminated) in polluted portions of these same Great Lakes waters and no recovery is presently evident. The recovery of *Hexagenia* in western Lake Erie is a signal which



Hexagenia recovery and Diporeia decline in the Great Lakes.

Source: Thomas Edsall, U.S. Geological Survey, Biological Resources Division, Ann Arbor, MI, unpublished data. Figure created by Melanie Neilson, Environment Canada

shows clearly that properly implemented pollution controls can bring about the recovery of a major Great Lakes mesotrophic ecosystem.

Future Pressures

Hexagenia are sensitive to periodic occurrences of anoxic (lacking oxygen) bottom waters resulting from excessive nutrient inputs; and toxic pollutants, including oil and heavy metals, which accumulate and persist in the lakebed sediments. Stormwater runoff from impervious surfaces and combined sewer overflows are significant sources of these pollutants.

Acknowledgments

Author: Thomas Edsall, U.S. Geological Survey, Biological Resources Division, Ann Arbor, MI.

Preyfish Populations

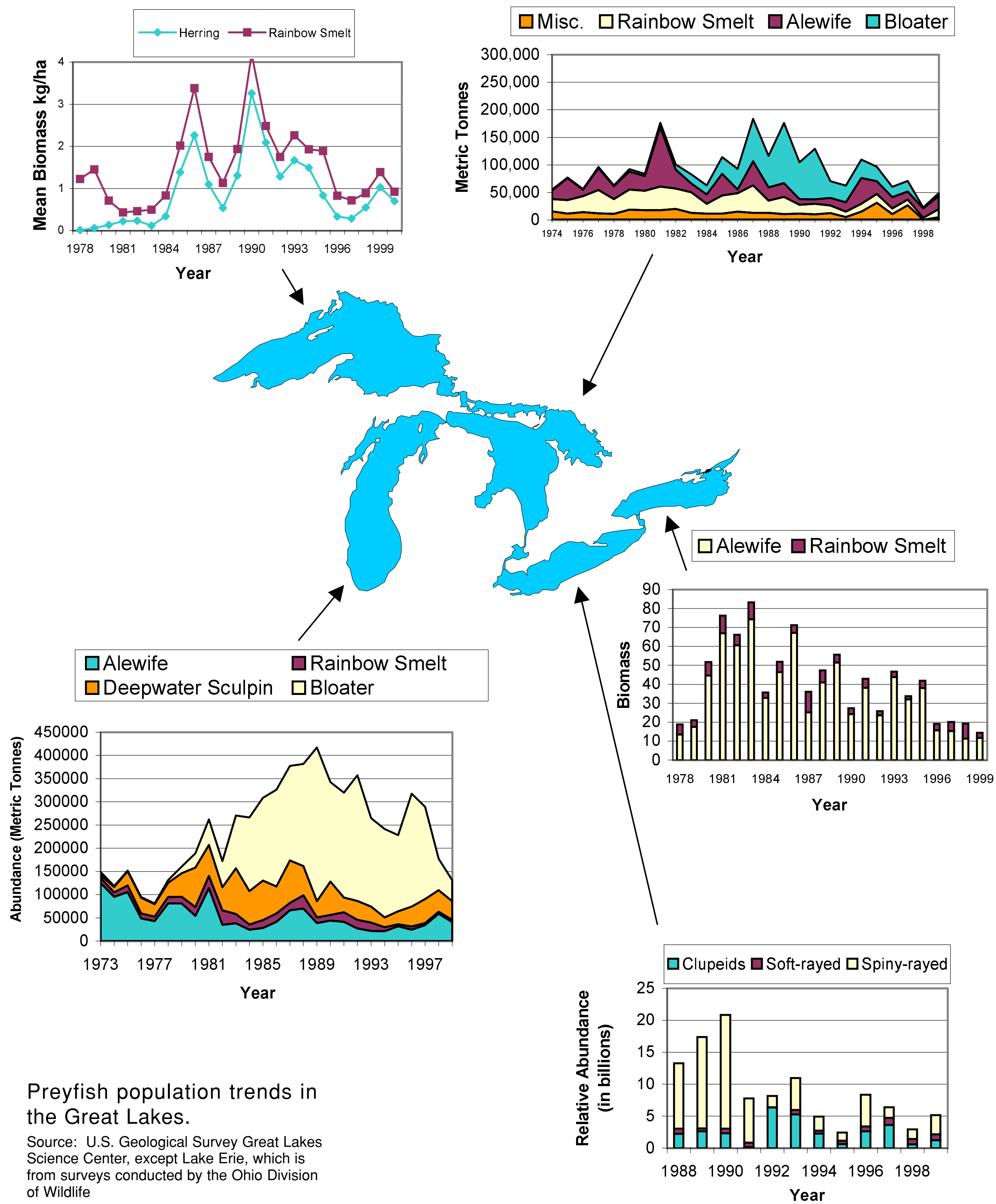
Assessment: Mixed

Purpose

This indicator directly measures the abundance and diversity of preyfish populations, especially in relation to the stability of predator species which are necessary to maintain the biological integrity of each lake.

State of the Ecosystem

Lake Superior. The population of lake herring has declined in recent years, believed to be the result of environmental factors rather than parental stock size. In contrast, rainbow smelt biomass has remained



Preyfish population trends in the Great Lakes.

Source: U.S. Geological Survey Great Lakes Science Center, except Lake Erie, which is from surveys conducted by the Ohio Division of Wildlife low and is likely controlled by predation from trout and salmon. Sculpins remain at low but consistent levels of abundance.

Lake Michigan. Alewives and smelt remain at lower levels than in previous years, apparently controlled in large part by predation pressure. Bloater biomass continues to decline due to lack of recruitment and slow growth. Sculpins continue to contribute a significant portion of the preyfish biomass.

Lake Huron. The decline in bloater abundance has resulted in an increased proportion of alewives in the preyfish community. Predation pressure may be an important force in both alewife and rainbow smelt populations. Sculpin populations have varied over time, but have been at lower levels in recent years.

Lake Erie. The preyfish community in Lake Erie has a high species diversity, but recently it has shown declining trends in all three basins. In the eastern basin, rainbow smelt (soft-rayed) have shown significant declines in abundance. In the western and central basins, white perch (spiny-rayed) and rainbow smelt have declined. Gizzard shad and alewife (clupeids) abundance has been quite variable across the survey period.

Lake Ontario. Alewives and to a lesser degree rainbow smelt dominate the preyfish population. Alewives had declined to low levels; though this species has exhibited strong 1998 and 1999 year classes (a year class refers to all the fish of a particular species born that year) which have recently increased their abundance. Rainbow smelt show some increase due to influence of 1996 year class, but the scarcity of large individuals indicates heavy predation. Overall, shifts to deeper water have been noted in fish distributions and may be related to establishment of zebra mussels. Sculpin populations have declined and remained at low levels since 1990.

Future Pressures

Preyfish populations are likely to be impacted by predation by salmon and trout, pressures from *Dreissena* (zebra and quagga mussels) populations, and dramatic declines in *Diporeia* (scud) populations.

Acknowledgments

Author: Guy W. Fleischer, U.S. Geological Survey Great Lakes Science Center, Ann Arbor, MI.

Contributions from Robert O'Gorman and Randy W. Owens, U.S. Geological Survey Great Lakes Science Center, Lake Ontario Biological Station, Oswego NY, Charles Madenjian, Gary Curtis, Ray Argyle and Jeff Schaeffer, U.S. Geological Survey Great Lakes Science Center, Ann Arbor, MI, and Charles Bronte and Mike Hoff, U.S. Geological Survey Great Lakes Science Center, Lake Superior Biological Station, Ashland, WI., and Jeffrey Tyson, Ohio Div. of Wildlife Sandusky Fish Research Unit, Sandusky, OH.

All preyfish trend figures are based on annual bottom trawl surveys performed by U.S. Geological Survey Great Lakes Science Center, except Lake Erie, which is from surveys conducted by the Ohio Division of Wildlife.

Spawning-Phase Sea Lamprey Abundance

Assessment: Mixed

Purpose

This indicator estimates the abundance of sea lampreys in the Great Lakes, which has a direct impact on the structure of the fish community and health of the aquatic ecosystem. Populations of large, native, predatory fishes can be diminished by sea lamprey predation.

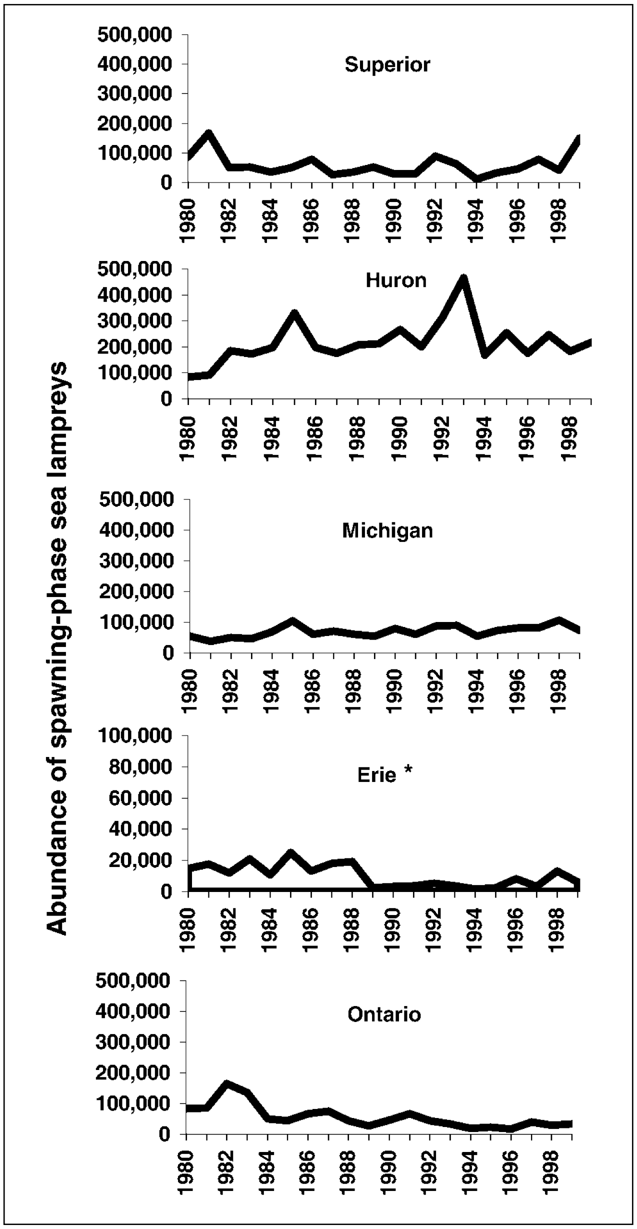
State of the Ecosystem

Lake Superior. During the past 20 years populations have fluctuated but remain at levels less than 10% of peak abundance. Although there is concern that abundance has increased since 1995, survival objectives for lake trout continue to be met.

Lake Michigan. Over most of the lake, populations have been relatively stable. However, an increase in the population in the north is caused by an expansion of the large population in Lake Huron moving into Lake Michigan.

Lake Huron. During the early 1980s, populations increased, particularly in the north. Through the 1990s Lake Huron contained more sea lamprey than all the other lakes combined. Lake trout restoration activities were abandoned in the northern portion of the lake during 1995 because so few lake trout were surviving to maturity because of attacks by sea lamprey. An integrated control strategy was initiated in the St. Marys River in 1997, including targeted application of a new bottom-release lampricide, enhanced trapping of spawning animals, and sterile-male release.

Lake Erie. Lamprey abundance has increased since the early 1990's to levels that threaten the lake trout success. An assessment during 1998 indicated that



Total lakewide abundance of sea lamprey estimated during the spawning migration. *Note the scale for Lake Erie is 1/5 larger than the other lakes.

Source: Gavin Christie and Jeffrey Slade, Great Lakes Fishery Commission, Rodney McDonald, Department of Fisheries and Oceans Canada, and Katherine Mullett, U.S. Fish and Wildlife Service

the sources of this increase were several streams in which treatments had been deferred due to low water flows or concerns for non-target organisms.

Lake Ontario. Abundance of spawning-phase sea lampreys has continued to decline to low levels throughout the 1990s.

Future Pressures

As water quality improves in Great Lakes tributaries so does the potential for sea lampreys to colonize new locations. Short lapses in control can result in rapid increases in abundance. Significant additional control efforts, like those on the St. Marys River, may be necessary to maintain suppression.

Acknowledgments

Author: Gavin Christie, Great Lakes Fishery Commission, Ann Arbor, MI.

Native Unionid Mussels

Assessment: Mixed, deteriorating

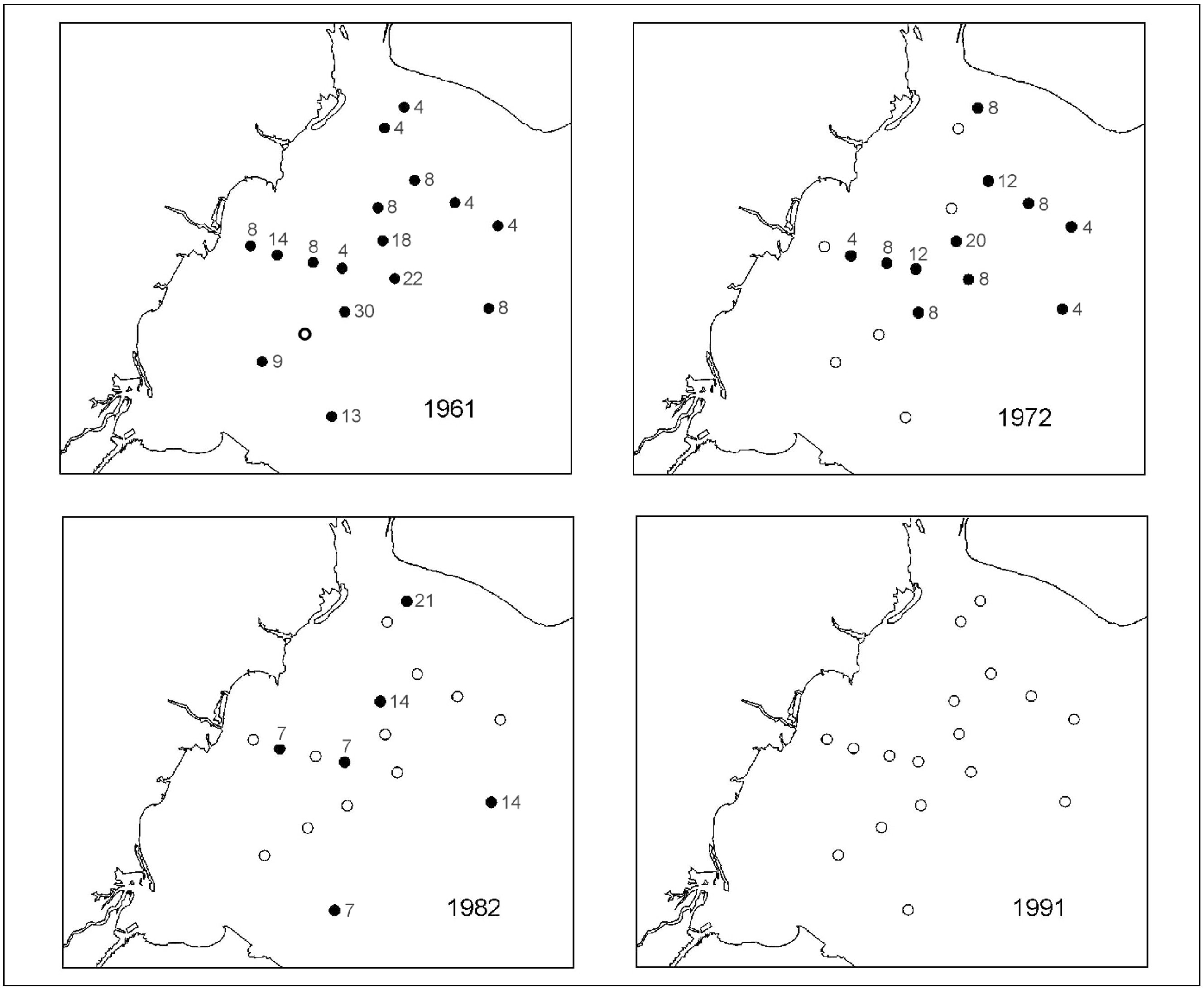
Purpose

Unionid distribution and abundance patterns reflect the general health of the aquatic ecosystem, and in particular those components interacting with the bottom substrates. Unionid mussels are long-lived, relatively sedentary animals, which are highly sensitive to habitat degradation, organic, inorganic, and metal pollutants, and biofouling by zebra mussels.

State of the Ecosystem

Many species of unionid mussels are listed as endangered or threatened. Most unionid populations in the Great Lakes and associated watersheds have declined as a result of decades of habitat alteration such as dredging, urbanization, increased sedimentation, and shoreline armouring. Additional stresses include changes in fish distribution, chemical pollutants in the water column and sediments and the arrival of competitive and predatory non-native species.

Unionid species diversity and density have severely declined in the open waters of Lake Erie, the Detroit River, and Lake St. Clair since the arrival of zebra mussels in the mid-1980s. Many sites do not contain any live unionids. Healthy and diverse



Abundance of freshwater mussels (numbers/m^2) collected in 1961, 1972, 1982 and 1991 from 17 sites in the western basin of Lake Erie. Black circles indicate the presence of native unionid mussels and the number indicates the quantity found at the test site. White circles indicate the absence of native unionid mussels.

Source: T. Nalepa, National Oceanic and Atmospheric Administration, B. Manny, J. Roth, S. Mozley, and D. Scholesser

communities, however, were recently discovered in Lake Erie in nearshore areas with firm substrates, in soft sediments associated with coastal marshes, and in a coastal marsh in the St. Clair River delta.

Future Pressures

Pressures on the native unionid mussel populations include: zebra mussel expansion (biofouling); changes to native fish community structure by non-native species (unionid reproductive cycles contain a parasitic larval stage requiring specific fish hosts); increasing urban sprawl; development of factory farms; and elevated use of herbicides.

Acknowledgments

Authors: S. Jerrine Nichols, U.S. Geological Survey Great Lakes Science Centre, Ann Arbor, MI and Janice Smith, Environment Canada, Burlington, ON.

Lake Trout

Assessment: Mixed

Purpose

This indicator tracks the status and trends in lake trout populations, and it will be used to infer the basic structure of cold water predator and prey communities and the general health of the ecosystem. By the late 1950s, lake trout were extirpated throughout most of the Great Lakes. Full restoration will not be achieved until natural reproduction is re-established and maintained.

State of the Ecosystem

Lake trout abundance dramatically increased in all the Great Lakes shortly after the initiation of sea lamprey control, stocking, and harvest control. Natural reproduction is now widespread in Lake Superior, and stocking has been discontinued throughout most of the lake. Densities of wild fish have exceeded that of hatchery-reared fish since the mid 1980s. Unfortunately natural reproduction is at very low levels or non-existent in the rest of the Great Lakes, therefore populations in these waters are maintained solely by stocking.

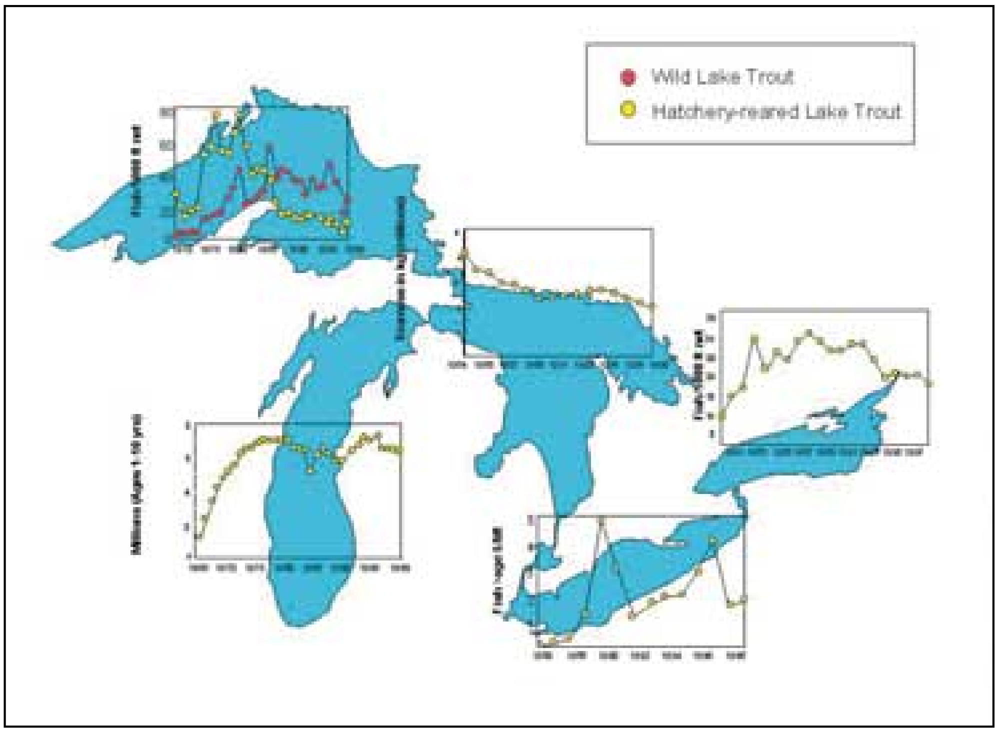
Future Pressures

Predation on newly hatched lake trout larvae by native and non-native predators is a problem. Excessive sea lamprey predation will result in few fish reaching sexual maturity. Hatchery-reared fish appear unable to select suitable substrate for egg deposition and genetic diversity is lacking in the strains of hatchery-reared fish stocked into the Lakes. Early mortality syndrome (EMS) of fish larvae is thought to be due to thiamine deficiencies in the parental diet of alewives.

Acknowledgments

Author: Charles Bronte, U.S. Fish and Wildlife Service, Green Bay, WI.

Contributions by James Bence, Michigan State University, East Lansing, MI, Donald Einhouse, New York Department of Environmental Conservation, Dunkirk, NY, and Robert O'Gorman, U.S. Geological Survey, Oswego, NY.



Lake trout abundance in the Great Lakes.

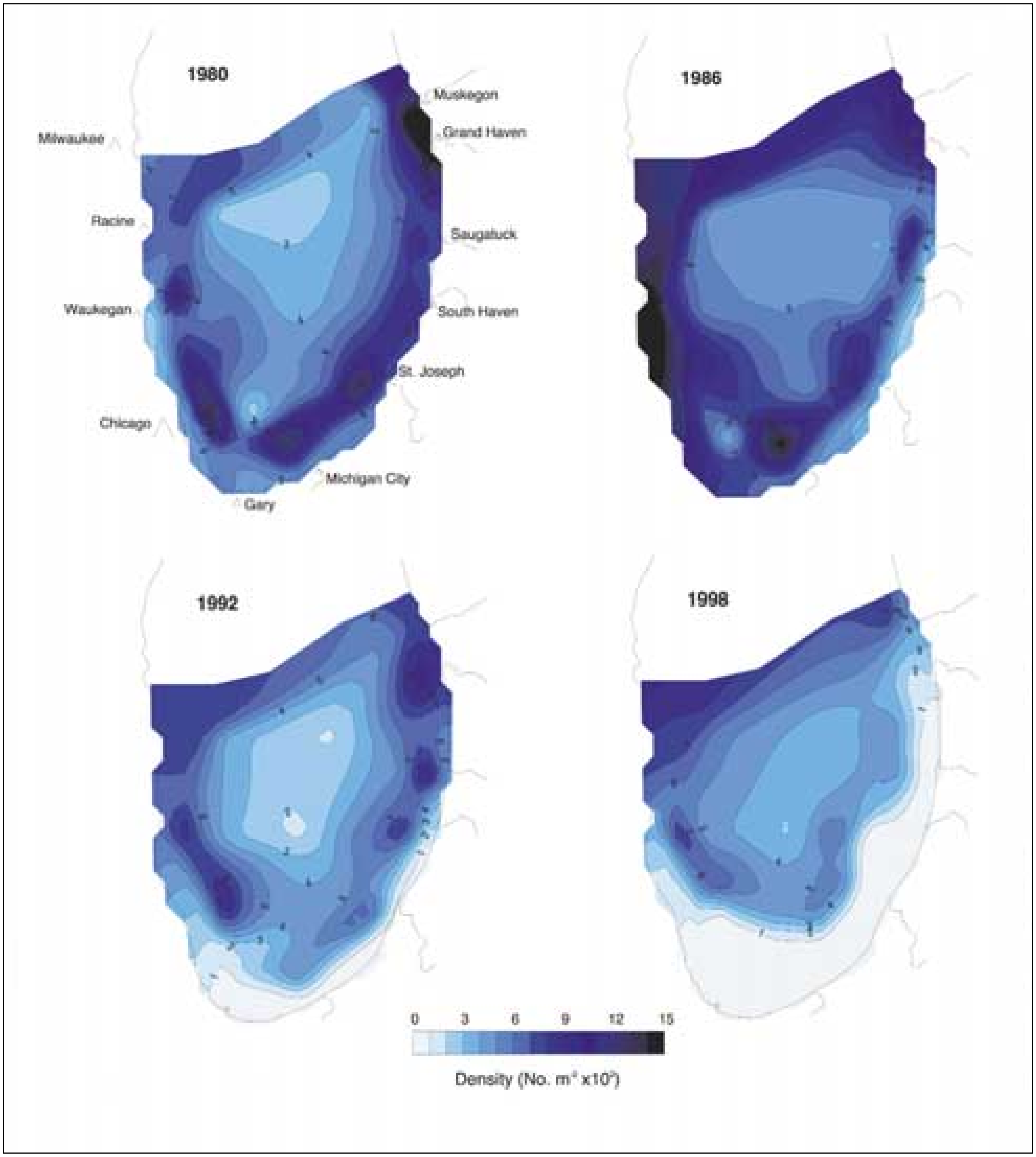
Source: R.L. Eshenroder, Great Lakes Fishery Commision, J.W. Peck, and C.H. Olver

Scud *(Diporeia hoyi)*

Assessment: Mixed, deteriorating

Purpose

This indicator provides a measure of the biological integrity of the offshore regions of the Great Lakes. It consists of assessing the abundance of the benthic macroinvertebrate *Diporeia*, which are the most abundant benthic organisms in cold, offshore regions of each of the lakes, and which are a key component in the food web of offshore regions.



Density (numbers/m^2 x 10^3) of Diporeia in the southern basin of Lake Michigan between 1980 and 1998. Note recent declines in the southeastern portion of the basin.

Source: Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration